

## SPORES AND POLLENS FROM A PERMIAN-TRIASSIC TRANSITION, N.S.W.

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(Plates v-vi; two Text-figures.)

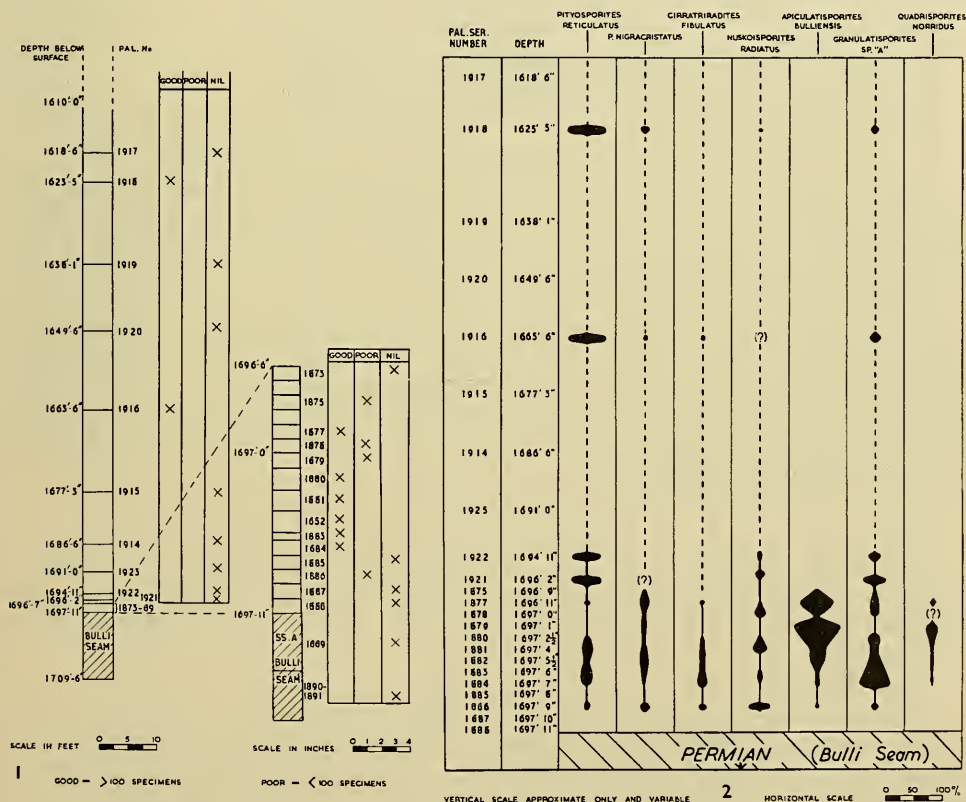
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## Synopsis.

An account is given of an investigation of the microspore and megaspore contents of some sections of strata above the Bulli seam, encountered during the drilling of a bore at Appin. One new genus and six new species were encountered and taxonomic descriptions of these are given, with preliminary notes on three other microspore and megaspore types.

## INTRODUCTION.

The material examined in this study of spores and pollens comprised the roof shales of the Bulli seam and 87 feet of the overlying Lower Narrabeen sediments. It was taken from Appin Bore No. 4, put down by Australian Iron and Steel Limited. An indication of the sampling depths and of the quality of spore preservation is given in Text-figure 1.



Text-fig. 1.—Sampling depths and the quality of spore preservation.

Text-fig. 2.—Distribution of sporomorphs in Appin Bore No. 4.

Examination of the megaspore and microspore content showed that a transition zone extended from 2 in. to 15 in. above the Bulli seam. This zone was characterized by a dominant *Apiculatisporites* species and an easily recognized cristate tetrad, in association with other types which were undoubtedly of Triassic age. The presence of numerous small megaspores further indicated a Triassic rather than a Permian age. In the sediments more than 15 in. above the Bulli seam only the obviously Triassic sporomorphs occurred (Text-fig. 2).

It has long been recognized that the macroscopic fossil record indicates the presence of a transition zone overlying the Bulli seam (Etheridge, 1892; Dun, 1901, 1910). Walkom (1925) considers this flora to be more closely related to the *Glossopteris* than to the Thinnfeldia. Though not identical with *Apiculatisporites* species found in the various Permian floras, *Apiculatisporites bulliensis*, new species, shows some superficial resemblance to *Apiculatisporites cornutus* of the Greta Coal Measures. It would be of great interest if fertile strobili of *Schizoneura gondwanensis* were available for comparison with both the above-mentioned common transition bed sporomorphs.

The microspore assemblage in the flora of the roof shales of the Bulli seam is much less varied than that of the Thinnfeldia flora of the Middle and Upper Narrabeen Formations. Of the samples examined, few contained well-preserved spores, and in even the best of these the specimens were not numerous. Holotypes and paratypes of the new species are preserved in the palynological herbarium of the Coal Research Section.

#### TAXONOMIC DESCRIPTIONS.

##### (a) SPORITES.

Division SPORITES H. Potonié, 1893.

Subdivision TRILETES Reinsch, 1883.

Genus APICULATISPORITES (Ibrahim, non Bennie and Kidston) Potonié and Kremp.

APICULATISPORITES BULLIENSIS, n. sp. (Pl. v, figs. 3-5.)

Amb circular or slightly oval. Trilete, laesurae indistinct, extending almost full radius. Exine  $2-4\mu$ , opaque. Ornamented with blunt conical processes  $1\mu$  or less in diameter,  $1-1\frac{1}{2}\mu$  in length, and  $2\mu$  apart. *Dimensions* (27 specimens): Diameter  $20-40\mu$  (mean  $29\mu$ ).

Probably owing to its small size and comparatively thick exine, this sporomorph is particularly resistant to corrosion and forms a useful indicator of the sediments of the Bulli transition zone. It somewhat resembles *A. cornutus* (Balme and Hennelly, 1956), of the Greta Coal Measures, except for its slightly smaller size, smaller conical processes, and wider spacing between spine bases. It is much more prolific in the Bulli transition zone than *A. cornutus* has been found to be in any of the Permian sediments examined by the author.

*Type Locality*: Appin Bore No. 4 from 1696 ft. 10 in. to 1697 ft. 5 in.

Genus QUADRISPORITES, n. gen.

The name *Quadrисporites* is proposed as a form genus for persistent tetragonal or hexagonal tetrads of microspores of vascular plant origin but otherwise of unknown affinities, and whose dehiscence mechanism is either alete or so obscured as to be indeterminate.

*Genotype*, *Quadrисporites horridus*, n. sp.

The morphology of the tetrad suggests the monoalete condition, but the cohesion of the tetrad even under adverse conditions of preservation indicates that it must be at least functionally alete. This unusual characteristic results in isolated spores being in a very small minority. Such spores are so poorly preserved that ruptures in the exine may not be related to dehiscence. As the type normally encountered is the tetrad it is preferable to classify it as such, rather than to attempt correlation with individual form genera based on dehiscence and ornamentation (Potonié and Kremp, 1954).

The term *Tetrasporites* has been applied to spores of presumed Ulvacean affinity (Fliche, 1886).

QUADRISPORITES HORRIDUS, n. sp. (Pl. v, figs. 6-7.)

Tetragonal tetrads of spores approximately spherical and of similar appearance and dimensions. Exine  $1\mu$  in thickness but opaque owing to heavy ornamentation. Examination of detached individuals does not disclose the type of dehiscence apparatus. Probably functionally alete. Ornamentation, a confused system of filiform cristae. Processes  $1\mu$  in diameter and  $2-3\mu$  in length superimposed on an interrupted micro-reticulum. *Dimensions* (20 individual spores, one each from 20 tetrads): Diameter  $23-37\mu$  (mean  $28\mu$ ).

This sporomorph is very useful as a means of identifying the Bulli transition zone in the Appin Bore. The tetrad formation is persistent even in corroded material, and

TABLE 1.

*Palynological summary:* Lowest Triassic overlying the Bulli seam (Permian), showing the transition zone and sediments to 75 feet above in green and grey shales (Lower Narrabeen Formation).

Pal. No.	Depth (ft.) (in.)	Thickness (in.)	<i>Laescheisporites limpidus</i>	<i>L. cf. amplius</i>	<i>L. sp.</i>	<i>Pityosporites reticulatus</i>	<i>P. nigraoristatus</i>	<i>P. sp.</i>	<i>Cirratiradites fibulatus</i>	<i>Muskosporites radiatus</i>	<i>Entylissa sp. (?)</i>	<i>Marsupipollenites sp.</i>	<i>Leiotriletes sp.</i>	<i>Sphaerites sp.</i>	<i>Apiculatisporites bulliensis</i>	<i>A. sp. (?)</i>	<i>Acanthotriletes sp.</i>	<i>Granulatisporites sp. "A"</i>	<i>G. sp.</i>	<i>Lycopodium cf. austroclavatidites</i>	<i>Reticulatisporites sp.</i>	<i>Quadratisporites horridus</i>	<i>Incertae sedis</i>	<i>Megaspore type "A"</i>	<i>Megaspore type "B"</i>	<i>Algal resins</i>	<i>Anthracolite</i>	No. of specimens observed	Preservation: Good, Fair, Poor, Nil		
1917	1618	1																											N		
1918	1623	1			(?)	72	13	5		1							1	7		1			1					100	P		
1919	1638	1½																											N		
1920	1649	2																											N		
1916	1663	1		1		67	3	1	2	(?)				2	(?)		19	4	(?)				3					100	P		
1915	1677	1																											N		
1914	1686																										x		N		
1923	1691	2																									x	x	N		
1922	1695	1				X				x								x					x				x	x	N		
1921	1696 2	1				X	(?)	x		x			x					x	x							x	x	33	F/P		
1873	1696 7	1																											N		
1875	1696 9	1						x						x			x												3	P	
1877	1696 11	1				5	7	x	2	2				58			15	3				8						100	G		
1878	1697	1						x		x				x			x					(?)							8	P	
1879	1697 1	1						x						XX								X							23	P	
1880	1697 2½	1½				4	4		2	2				59			19				10				x			100	F		
1881	1697 4	1½	1			16	9		4	23	2			29			14				2			10%	x			100	G		
1882	1697 5½	1½		x		10	15	1	8			5	x	x	23		23	2	2	4								100	P		
1883	1697 6	½				17	8	2	13	6		x			4		1	40				3	2	2				100	F		
1884	1697 7	1	1		x	12	5	1	17	1				8	x		53				x	2		x		x		100	P		
1885	1697 8	1																									x		N		
1886	1697 9	1				13	16	5	10	40					5		10						X	X					63	P	
1887	1697 10	1																									x		N		
1888	1697 11	1																									x		N		
1889	1698 3	4																											N		
1890	1709 6	129																									x		N		
1891	1709 6	131																									x		N		

X = dominant; x = presence; (?) = doubtful presence.

Type of sediment: 1917-1888, Clastic sediments, mainly green-grey shales; 1889, Bulli seam S.S.A.; 1890, Bulli seam minus dirt; 1891, Bulli seam plus dirt.



quite characteristic in appearance. In detached corroded specimens the remains of the interrupted reticulum forming the cristate system resemble corroded specimens of *Apiculatisporites bulliensis* and *Granulatisporites* sp. "A".

It is recommended that only coherent tetrads be recorded in palynological examinations. In the palynological summary (Table 1) each tetrad has been recorded as a separate entity.

*Type Locality*.—Appin Bore No. 4 at 1697 ft. 2 in.

Subdivision ZONALES Bennie and Kidston emend. Potonié and Kremp.

Genus CIRRATIRADITES (Wilson and Coe) Potonié and Kremp.

CIRRATIRADITES FIBULATUS, n. sp. (Pl. v, figs. 8-9.)

Spore complex, consisting of a central body with an equatorially attached transparent membranous wing. Amb of central body circular or rounded triangular, wing approximately concentric with body. Trilete sutures fairly straight, extending to apices of wing. Lips  $1\mu$ . Ornament, body and wing granulate with grana about  $1\mu$  and closely spaced, and microreticulate with muri  $1\mu$  and lumens of  $4\mu$  over the body. This reticulation extends also to the outer wing where the lumens are reduced to about  $2\mu$  and are scarcely discernible. Wing overlap  $1\mu$  or more, and often difficult to detect. *Dimensions* (50 specimens):  $30-35\mu$  overall diameter (mean  $40\mu$ ), body diameter  $22-47\mu$  (mean  $29\mu$ ).

Superimposition of muri on grana gives an appearance of grana larger than  $1\mu$ .

A somewhat similar but psilate-winged and slightly smaller-dimensioned *Cirratriadites* sp. is recorded by de Jersey (1949) as type T32C, from the Triassic of Ipswich, Queensland.

*Type Locality*.—Appin Bore No. 4 from 1697 ft.  $2\frac{1}{2}$  in. to 1697 ft. 9 in.

(b) Division POLLENITES.

Subdivision SACCITES Erdtman.

Genus NUSKOISPORITES Potonié and Klaus.

NUSKOISPORITES RADIATUS, n. sp. (Pl. v, figs. 10-12.)

*Synonymy*: Type 34C Taylor, 1953.

Amb, of both central body and bladder, circular. Trilete sutures indistinct. Dehiscence, sometimes by loss of the whole proximal face in the manner of an operculum, otherwise a triangular rent formed by the proximal face rolling back from the fully opened sutures, which extend the full radius of the body. Exine of the central body translucent and about  $1\mu$  in thickness; ornament very finely granulate on the proximal face and faintly reticulate on the distal face. Grana less than  $1\mu$ . Equatorial bladder is also finely granulate and finely microreticulate with muri less than  $1\mu$  in width and lumens  $1-2\frac{1}{2}\mu$ , exine transparent and thinner than that of body. Overlap  $7-12\mu$ . Radial folds usually present in the bladder. *Dimensions* (20 specimens): Total diameter  $70-110\mu$  (mean  $91\mu$ ), central body  $26-60\mu$  (mean  $45\mu$ ).

The general appearance is granulate except under high magnification, and superficially resembles *N. dulhuntyi* Klaus (Klaus, 1953). Size range is smaller, and radial folds are fairly characteristic. When ruptured with loss of the proximal face this species can only be recognized by the finely granulate wing ornament.

*Type Locality*.—Appin Bore No. 4 from 1697 ft. 0 in. to 1697 ft. 9 in.

Genus PITYOSPORITES Seward.

PITYOSPORITES NIGRACRISTATUS, n. sp. (Pl. v, figs. 13-15.)

Pollen bisaccate. Central body circular or subcircular, proximal cap unthickened and very finely granulate, with grana less than  $1\mu$ . Exine about  $1\mu$  in thickness. Crests prominent, and ranging up to  $7\mu$  in width. Bladders symmetrically disposed. Furrow indistinct, dehiscence often by irregular rupture with varying body opening. Bladder length is usually not greater than the longitudinal diameter of the central body, and bladder width is not greater than this dimension. Bladders ornamented with an irregular reticulum, often interrupted and sometimes appearing vermiculate.

The muri are less than  $1\mu$  and lumens vary from  $2-5\mu$ . *Dimensions* (20 specimens): Central body polar diameter  $30-45\mu$  (mean  $38\mu$ ), total span  $45-72\mu$  (mean  $61\mu$ ).

*P. nigracristatus* differs from *P. elliptica* (Cookson) Balme (Cookson, 1947; Balme, 1957) in that it has more obvious wing reticulation, slightly thicker wing tissue, and the wings do not project beyond the poles. Apart from its rather more robust structure, *P. nigracristatus* differs from *P. similis* Balme in having larger and irregular reticulation of wing and more prominent crests.

*Type Locality*.—Appin Bore No. 4 from 1696 ft. 9 in. to 1697 ft. 9 in.

PITYOSPORITES RETICULATUS, n. sp. (Pl. v, fig. 16; Pl. vi, figs. 17-18.)

Pollen grain bisaccate. Central body circular or tending to oval. Ornament finely granulate and microreticulate, with muri about  $1\mu$  in width and lumens  $4-6\mu$ . Exine within the lumen about  $1\mu$  thick and translucent to transparent. Furrow normal. Bladders symmetrically disposed on either side of the furrow, with prominent crests about  $5\mu$  in thickness. Outline of the whole pollen is approximately oval. Bladder width is variable but generally not as great as body diameter. Bladders externally microreticulate with prominent muri  $1\mu$  in width. In proximal view the reticulum obscures the central body. *Dimensions* (25 specimens): Body  $52-88\mu$  (mean  $63\mu$ ), total span  $63-137\mu$  (mean  $96\mu$ ).

The wings are prone to separate from the body with the crests attached, giving the appearance of a monolet sporomorph with thickened lips. In oxidized samples the muri and crests are darkened and render this pollen easily identifiable even in the fragmented state. It is the dominant of the sediments 34 ft. and 74 ft. above the Bulli seam in the Appin Bore No. 4.

*Type Locality*.—Appin Bore No. 4 1623 ft. to 1697 ft. 9 in.

#### (c) NOTES ON TWO MEGASPORES AND ONE TRILETE MICROSPORE.

MEGASPORE TYPE "A". (Pl. vi, figs. 21-22.)

Amb circular to rounded triangular. Trilete sutures about  $35\mu$  in width, extending almost full radius. Exine opaque,  $20-45\mu$  in thickness; contact face and laesural ridge visible in some specimens. Silhouette shows prominent muri. Ornamentation deeply reticulate with muri  $4-8\mu$  in width and  $10-15\mu$  in height. Lumens  $10-15\mu$ . Exine within the lumen is rugose. In corroded specimens the muri are persistent, the exine within the lumen becoming translucent. This megaspore is very common in the Appin Bore Transition Zone.

*Type Locality*.—Appin Bore No. 4 at 1697 ft. 4 in.

MEGASPORE TYPE "B". (Pl. vi, figs. 19-20.)

Amb rounded triangular, straight sutures  $10\mu$  in width extending almost full radius. Exine translucent to opaque,  $10-20\mu$  in thickness. Contact area (poorly developed) covers most of proximal surface. Ornamentation, reticulate with muri  $2\mu$  in width and lumens  $5\mu$  or less. Within the lumen the exine is granulate, with grana  $1\mu$  or less,  $1-2\mu$  apart.

Both megaspores appear to be comparatively small, with diameters of  $250-500\mu$ , but as most of the specimens examined are incomplete it is inadvisable to attempt to specify the size range more definitely at this stage.

*Type Locality*.—Appin Bore No. 4 at 1696 ft. 11 in.

Genus GRANULATISPORITES (Ibrahim) Potonié and Kremp.

GRANULATISPORITES sp. "A". (Table 2; Pl. vi, figs. 23-24.)

Amb circular, with a faintly irregular outline due to ornament. Trilete sutures indistinct, extending almost full radius. Lips thin,  $1\mu$  or less. Contact area rarely identifiable. Dehiscence often by rupture. Exine  $2\mu$  in thickness, translucent. Ornamentation, granulate with grana  $1\mu$  or less, about  $2\mu$  apart. *Dimensions* (30 specimens):  $20-74\mu$  diameter (mean  $45\mu$ ).

In the poorly preserved specimens obtained at Appin Bore No. 4 the corrosion of the exine in patches presents a false reticulate appearance in high focus. The silhouette, however, shows only grana of less than  $1\mu$  in height and no indication of muri. It is possible that this sporomorph includes two varieties, the smaller  $20-45\mu$  (mean about  $35\mu$ ) and the larger  $36-74\mu$  (mean about  $54\mu$ ) in diameter; the difference, apart from size, being a slightly thinner exine in the larger variety.

*Type Locality*.—Appin Bore No. 4 1694 ft. 11 in. to 1697 ft. 9 in.

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TABLE 2.  
*Distribution of Appin Sporomorphs in Other Australian Triassic Sediments.*

	Thinnfeldia Flora, N.S.W.*	Callide.†	Leigh Creek.‡
<i>Pityosporites reticulatus</i> .. ..	—	—	—
<i>P. nigraeristatus</i> .. ..	×	—	—
<i>Cirratriradites fibulatus</i> .. ..	—	—	—
<i>Nuskoisporites radiatus</i> .. ..	?	—	×
<i>Apiculatisporites bulliensis</i> .. ..	—	—	—
<i>Granulatisporites</i> sp. "A" .. ..	×	—	—
Megaspore type "A" .. ..	—	—	—
Megaspore type "B" .. ..	×	—	—
<i>Lueckisporites</i> spp. .. ..	×	—	—
<i>Lycopodium</i> spp. .. ..	×	—	—
<i>Quadrisporites horridus</i> .. ..	—	—	—

\* Two samples, a mudstone and an anthraxolite shale.

† A single sample.

‡ Discussions with G. H. Taylor, and a few samples of his Leigh Creek specimens.

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## EXPLANATION OF PLATES V-VI.

Magnification is 500 diameters in every case except Figures 19 and 21, where it is 50 diameters.

## Plate v.

3: *Apiculatisporites bulliensis*, showing ornament. 4: *A. bulliensis*, showing sutures. 5: A tetrad of *A. bulliensis*. 6: *Quadrisporites horridus*, showing dark cruciform of contact faces. 7: *Q. horridus*, ornament. 8: *Cirratriradites fibulatus*, amb. 9: *C. fibulatus*, wing and body ornament. 10: *Nuskoisporites radiatus*, trilete dehiscence. 11: *N. radiatus* with dehiscence by rupture, showing the proximal portion still hinged along the lower margin and opened in the manner of an operculum. 12: *N. radiatus*, ornament. 13-15: *Pityosporites nigracristatus*. 16: *P. reticulatus*.

## Plate vi.

17, 18: *P. reticulatus*. 19: Megaspore type "B" in reflected light showing contact face. 20: Megaspore type "B" fragment, showing ornament in transmitted light. 21: Megaspore type "A" in transmitted light. 22: Megaspore type "A" fragment, showing ornament in transmitted light. 23, 24: *Granulatisporites* sp. "A".